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of Yale College, no less than twenty millions of meteors enter the earth's atmosphere each twenty-four hours, many of these reaching the earth's surface as the finest of meteoric dust. This dust, which like the Logan county rocks contains nickel and cobalt and iron and manganese and other chemical elements, has been found to cover the roofs of the houses of the city of Quito in South America after an unusual meteoric display. It has been found universally present in the ice and snow of the Alpine and Arctic regions. It may be collected at any time from the atmosphere by exposing to the air a properly prepared surface, as was done by Tissandier. It was dredged from the bottom of the deepest Atlantic ocean by the Challenger expedition. There is no doubt that the old Tertiary ocean of western Kansas received this meteoric dust as do the oceans of the present time. If the mud and sand and pebbles of our Atlantic should ever become hardened into rock, and form a part of the dry land, the chemists of that time would be able to detect the nickel and cobalt dust, whose meteoric origin has been established by our chemists and meteorologists. We are now applying the same test to the bottom of the old Tertiary ocean, now a part of the dry land, and find convincing evidence that then as now the atmosphere was traversed by multitudes of meteoric bodies producing the same effect as they now produce. This disintegrated meteoric matter sinking to the bottom of the ocean then as now, would be distributed by the under-currents and lodged in cavities and depressions of the ocean-bottom according to its specific gravity. Such a depression or basin seems to have been struck by the Logan county miners. But these deposits are not suitable for mining, for the quantity of nickel-dust is too small to warrant the expectation of any returns upon the money invested.

THE EVAPORATIVE POWER OF KANSAS COALS.

BY LUCIEN I. BLAKE, LAWRENCE, KANSAS.

The commercial value of coal is not a criterion of its actual heating power. The cost of mining, distance from market, competition, etc., determine the former, while the latter depends solely upon the coal *per se*. Further, the *total* amount of heat obtained by the complete combustion of a given amount of coal exceeds largely — often by fully 100 per cent. — the amount usefully obtained in practice. Confining ourselves to coal used in the production of steam, this is due to imperfect combustion, to arrangement of grate and heating surface, methods of firing, etc., etc. The same coal in different furnaces may give different results. Duty tests upon any one plant give the relative values of coals for that plant only. There is, however, an important method of comparing the actual heating values of coals which is independent of commercial values and of diversified conditions of burning. It is by measuring the heat given out by coals *under perfect combustion* expressed in terms of their evaporative powers. To this end, therefore, it is quite customary to compare coals according to their evaporative powers. By this is meant how many pounds or kilograms of water at 212° F. will be converted into steam, also at 212°, and under 760 mm. pressure, by one pound or one kilogram of coal. The object of the present investigation is to compare coals from the different Kansas veins according to their evaporative powers as defined above.

It might be mentioned that this investigation has been undertaken in conjunction with E. H. S. Bailey, Professor of Chemistry at the State University, who will make report upon the chemical analysis of the same specimens of coal. Both investigations are preliminary to a report to the State Board of Agriculture. The coals for testing have been collected personally by one or both of us at the mines. A variety of average samples was taken from various parts of a mine—block, nut, and slack. These were mixed together and finely powdered. The resulting four or five pounds were considered a fair representative of the coal from that mine, and also had not been selected by interested parties. The burnings were made by Thompson's calorimetric method. The apparatus was constructed by Alex. Wright, of London, and is the one employed by the English Government in the purchase of its coals for railway and marine, as well as by many of the large manufacturers in that and in this country. It is based upon the following principles. The latent heat of water represents the amount of heat which disappears when water at 212° is converted into steam at 212°. This amount is 537.22 gram-degrees or calories. Consequently the number of degrees C. through which 1 gram of coal will raise 537.22 grams of water will be a measure of the evaporative power of that coal. Evidently the absolute value of the latent heat of water is immaterial. The apparatus is arranged to produce the complete combustion of 2 grams of coal in 1,934 grams of water. To effect this perfect combustion, the coal, powdered to pass through a sieve 1,000 meshes to the square inch, is intimately mixed with about 22 grams of $KClO_3$ and KNO_3, three parts to one. This mixture, in a small copper cylinder, is covered with a larger copper cylinder like a diving-bell, with a series of holes around its base. The mixture is ignited by a fuse, the copper furnace covered with the larger cylinder, and the whole is plunged under the water. The $KClO_3$ and KNO_3 furnish oxygen for the complete combustion of the coal, the gaseous products forcing their way in bubbles up through the water. In their ascent the bubbles are robbed of their heat by the water. Upon completion of the burning, the rise of temperature is determined by an accurate thermometer. A description of this method of Thompson is given in the Encyclopædia Britannica, under the head "Coal." The corrections upon the instrument have been determined by experience and theory, as follows:

1. Loss of heat from radiation, conduction, and correction. The calorimeter jar was filled with water about 6° F. above the temperature of the room, and its rate of cooling determined. The refinement of the experiment does not require either Newton's or Dulay & Petit's Law of Cooling. The following table gives the results:

Time.	*Ther. No. 1, in calorimeter.*	*Ther. No. 2, 1 inch from calorimeter.*	*Ther. No. 3, 1 foot from calorimeter.*
11:45 A.M.	79.2° F.	23.8° C.	23.2° C.
11:50 "	79.1	23.4	23.2
11:53 "	79.0	23.4	23.2
11:55 "	78.95	23.4	23.15
11:58 "	78.80	23.4	23.1
12:00 M.	78.70	23.4	23.1
1:00 P.M.	76.80	23.4	23.1
2:00 "	75.30	23.3	......
1 h. 35 m.	Drop of 3.9° F.		

The loss is quite uniformly 0.03° F. in 1 minute. A burning requires about 3 minutes; hence the loss would be 0.1° F.

This loss is approximately compensated for by having the water in the calorimeter as much below the room-temperature before the burning as it is above at the close of the experiment.

2. Heat absorbed by metallic parts of the calorimeter. These parts weigh about 0.5 kilograms, with a specific heat of 0.095. Since there are approximately 2,000 grams of water, 2.4 per cent. must be allowed for absorption by the calorimeter.

3. Heat absorbed by the gases of combustion. This amount can be only approximated. The volume of the escaping gases is about 3,300 cubic centimeters. The rate of combustion is slow enough to allow these gases to issue into the air at about the temperature of the water, or about 5.4° F. above the room-temperature. Assum-

ing their specific heat to be on the average that of CO_2, for about 12° rise in temperature 0.9 per cent. must be lost.

4. The heat of the decomposition of the $KClO_3$ and KNO_3. This can be only approximately determined for the apparatus.

(*a.*) Two grams of pure carbon under combustion in the calorimeter gave 11,643 gram-degrees thermal effect. It is known that the perfect combustion of this amount of pure carbon should have produced 16,160 gram-degrees. The total loss is therefore 28 per cent. Of this, considering 3.3 per cent. as due to causes already mentioned in 2 and 3, 24.7 per cent. must be required for the decomposition of the oxygen-producing mixture.

(*b.*) In order to determine this amount in another way, if possible, the heat required for the decomposition of the 22 grams oxygen mixture was calculated in accordance with the methods and tables given by Pattison Muir.[*] This amount is as follows:

16.5 grams $KClO_3$ in decomposition gives out	1312	gram-degrees.
5.5 " KNO_3 " " absorbs	6144	"
Amount absorbed for 22 grams, oxygen mixture	4832	"
" " by apparatus, by radiation, etc., (33 per cent)	533	"
Total amount absorbed	5365	"
2 grams pure carbon should give	16,160	"

The loss, therefore, (by calculation,) is 33 per cent., which does not differ greatly from that obtained by (*a*), or 28 per cent.

(*c.*) No attempt to estimate the heating powers from the chemical analysis of the coal is considered valuable. In this connection, M. L. Grunow, in the *Engineering and Mining Journal*, vol. XVIII, states: "It is evident that the manner of combination of the elements in coals is too variable to make it possible to determine their true heating power from simple elementary analysis."

5. By error in the amount of coal taken. All the coal was weighed in balances reading to 0.5 milligrams. A possible error of 1 milligram in the weighing would affect the result by only 0.05 of 1 per cent., a negligible quantity.

6. By error in amount of water taken. An error of 3 grams was a possible limit with the balances employed, and this would introduce an error of 0.15 of 1 per cent., a quantity also negligible.

From the above results it is evident that the correction of 10 per cent., recommended by the manufacturers of the apparatus, and hitherto adopted by experimenters, is far too small. The total correction is probably not far from *30* per cent.

In the following tables, corrections of both 10 and 30 per cent. are given, the former to render the results readily comparable with those of other experimenters with the same apparatus.

DESCRIPTION OF THE COAL BEDS, BEGINNING WITH THE LOWEST.[†]

A. The Leavenworth vein, at Lansing and Leavenworth: 24-inch vein, about 720 feet below surface.
B. The Cherokee, in Crawford and Cherokee counties, at Pittsburg, Weir City and vicinity: 42-inch vein; from outcropping to 70 feet deep.
C. Upper vein in Crawford county, now worked as strippings and slopes; 18-inch vein.
D. The Fort Scott coals: chiefly slopes and strippings; 28 inches—14 inches.
E. The Linn county bed, at Pleasanton, La Cygne, &c.: 14-inch vein; 60 to 100 feet deep.
F. The Osage county veins, at Osage City, Carbondale, Burlingame and vicinity: Vein 18 to 20 inches; 35 to 85 feet deep.
G. Franklin county coal.
H. Cloud county coal.

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[*] The Elements of Thermal Chemistry: Muir. 1885. Appendix I.

[†] See also "Composition of Kansas Coals," by Prof. E. H. S. Bailey, in this volume, p. 46.

Specimens were taken from localities as widely distributed as possible over the vein — north, south, east, and west — particularly north and south, as the veins dip west and north. The results may be considered as fair representatives of the whole vein, and also as embracing the principal veins at present worked in the State of Kansas. These results are presented in the following table. For comparison sake there is included also tests of the best Indiana block coal (Clay county).

TABLES.

[NOTE.—About *one-half* the evaporative powers here given in the first column will be obtained in steam boilers.]

[NOTE.—Best Indiana Block gives 14.43 and 17.04 pounds evaporative power for 10 and 30 per cent. corrections, respectively.]

A.—CHEROKEE COALS.

(Pittsburg, Weir City, Scammonville, Frontenac, Stillson, &c.)

Number of sample.	*Pounds water at 212° evaporated, per pound coal.* CORRECTION ON APPARATUS.		*Duration of burning, seconds.*	*Remarks.*
	10 per cent.	*30 per cent.*		
1	13.53	15.97	40	
2	13.64	16.10	45	
3	13.01	15.35	45	
4	13.31	15.71	60	
5	13.31	15.71	60	Violent burning.
6	13.86	16.36	65	
7	13.53	15.97	50	Violent burning.
8	13.94	16.45	75	
9	13.42	15.84	90	
Average	13.51	15.94		
All samples mixed	13.42	15.84	80	

B.—CHEROKEE, (upper vein.)

(Pittsburg.)

1	12.43	14.67	55	
2	12.76	15.06	45	
3	13.31	15.71	60	
Average	12.83	15.14		
All samples mixed	12.54	14.80	60	

C.—FORT SCOTT COALS.

1	13.64	16.10	65	
2	13.09	15.45	60	
3	13.86	16.35	55	
Average	13.53	15.97		
All samples mixed	13.20	15.58	120	

D.—LEAVENWORTH COALS.

1	13.36	15.76	75	
2	12.25	14.46	80	Brown residue.
3	13.86	16.35	65	
Average	12.95	15.52		
All samples mixed	12.54	14.80	105	

E.—LINN COUNTY COALS.

(Pleasanton, La Cygne, &c.)

1	12.76	15.06	60	
2	12.76	15.06	70	
3	12.87	15.49	80	Brown residue.
4	12.54	14.80	75	
Average	12.73	15.10		
All samples mixed	12.76	15.06	100	

F.—Osage County Coals.

(Osage City, Scranton, Carbondale, Burlingame, &c.)

Number of sample.	*Pounds water at 212° evaporated, per pound coal.* CORRECTION ON APPARATUS.		*Duration of burning, seconds.*	*Remarks.*
	10 per cent.	*30 per cent.*		
1	11.88	14.02	110	Brown residue.
2	10.96	12.93	90	"
3	12.98	15.32	120	"
4	11.66	13.76	120	"
5	12.43	14.67	120	"
6	11.99	14.15	165	"
7	11.66	13.76	120	"
8	11.88	14.02	120	"
9	11.55	13.63	70	"
10	11.44	13.50	80	"
11	11.66	13.76	105	"
Average	11.76	13.96	.....	
All samples mixed	12.10	14.28	135	
G.—Franklin County Coal.				
1	12.32	14.54	125	....
H.—Cloud County Coal.				
1	9.90	11.68	135	....

SUMMARY.

From these results, the Kansas coals thus far examined are to be arranged in the following order as regards their evaporative powers.

[Note.—About *one-half* the evaporative powers here given under the 10 per cent. correction, will be obtained in practice.]

Order	*Name of coal.*	*Table.*	*Pounds water evaporated per pound coal.*		*Duration of burning—seconds.*	*Calories gram-degrees Centigrade.* CORRECTION.	
			10 per cent.	*30 per cent.*		*10 pr ct.*	*30 pr ct.*
1	Cherokee	A.	13.42	15.84	65	7206	8506
1	Fort Scott	C.	13.20	15.58	60	7088	8364
3	Linn County	E.	12.76	15.06	65	6852	8105
4	Cherokee, upper vein, Leavenworth,	B. D.	12.54	14.80	50 75	6734	7946
5	Franklin County	G.	12.32	14.54	125	6615	7806
6	Osage County	F.	12.10	14.28	115	6498	7668
7	Cloud County	H.	9.90	11.68	135	5316	6273
	For comparison: Best Indiana Block (Clay county)	....	14.43	17.03	....	7749	9144

The coals depreciate in their steam-producing powers from the southeastern part of the State toward the north and west. Prof. Bailey finds they depreciate in the amounts of fixed carbon in a similar order.

Physical Laboratory, State University, Oct. 1888.

THE COMPOSITION OF KANSAS COALS.

BY E. H. S. BAILEY, PH.D.

The eastern part of the State of Kansas is fortunately underlaid with a fair quality of coal. With the increased population, the introduction of important manufacturing industries, and the extension of the several lines of railway, there is